SUPPLEMENTING DAY-OLD PIGS WITH BOVINE COLOSTRUM OR MILK REPLACER

by

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Introduction

Successful farmers must always be looking for ways to increase production without excessively increasing input costs. In the case of pig producers, the specific goal is more pounds weaned. This can be accomplished through improved performance as reflected in growth rate, and through reduced death losses.

Most morbidity and mortality losses can be traced back to problems with either nutrition or disease. It follows, then, that management practices that bolster nutrient (energy) intake and immune system development can result in a more profitable farrowing enterprise.

Under natural conditions, a sow's colostrum provides the pig with the nutrients and immune factors necessary for growth and development. However, there are cases where this milk supply is either inadequate or nonexistent. Small pigs, pigs from large litters, pigs born late in the farrowing order, cold stressed pigs, and sick, especially scouring, pigs could all be considered at risk in this respect.

The pig producer faced with any or all of these conditions must find an additional source of energy and/or immunoglobulins if he wishes to minimize deaths and optimize growth. One possibility is supplementation with bovine colostrum. It is very similar to the natural source (sow colostrum), is probably readily available from a local dairy, stores easily by freezing, and contains high levels of both energy and immune factors. Another alternative might be administration of milk replacer, which is also a convenient, available source of energy.

This paper investigates the application of this practice on a large scale, under commercial conditions. Day-old pigs, blocked by birth weight, were either supplemented with bovine colostrum or isocaloric milk replacer, or assigned to a control group. Data were collected on scouring, weight gains, weaning weights, and survivability, and analyzed for all pigs, by litter size, and by weight classes.

It was anticipated that the pigs supplemented with colostrum would, due to the available energy and immunologic factors, display less scouring and mortality, and possibly improved weight gains and/or weaning weights. Pigs receiving replacer were expected to perform at a level somewhere between the colostrum pigs and the controls. An economic analysis was planned to follow up the feeding trial.

Review of Literature

The major goal of any farrowing operation is to wean more pounds of pigs without completely offsetting these gains with increased production costs. There are essentially two ways to accomplish this: reducing mortality and improving early growth rate. The first is an area in which the industry especially has room for improvement. Twenty percent of live-born piglets do not survive to weaning (McCallum, _et.al._, 1977; Kelley, _et.al._, 1982), with over half of these deaths occurring by the end of day 2 (English and Smith, 1974).

Early Mortality. Numerous factors contribute to early baby pig mortality. English and Smith (1974) categorized the deaths of 236 live-born piglets, attributing 88.2% of them to five groups of primary factors: congenital and genetic abnormalities, 12.3%; extreme weakness at birth, 8.5%; weakness relative to littermates, 6.4%; crushing, 18.2%; normal pigs not getting enough milk, 42.8%. They estimated that half of those pigs crushed were already in a weakened state, and they suggested that the weakened piglets in all categories had suffered prenatal anoxia. It was also noted that litters with greater variation in birthweight suffered more mortality. This agrees with statements made by Hendrix, _et.al._ (1978), who believed the primary reason newborn pigs die was because they are weak at birth and cannot compete effectively with littermates, leading to lower colostrum and milk consumption, and eventual starvation and death. Aumaitre and Seve (1978) proposed their own list of factors contributing to survival: birth weight, thermal environment, litter size, pathology, and nutrition, the last two of which are directly affected by colostrum intake. And Hendrix, et.al. (1978) found that pigs that survived to 21 days had required less ($P<.05$) time to be expelled from the dam, had higher ($P<.001$) gamma globulin concentrations at 12 hours, were heavier ($P<.05$) at birth, and tended to be born earlier ($P<.10$) in the litter.

Much of these data, either directly or indirectly, stress the importance of colostrum intake to baby pig survival. Colostrum provides the young pig with 90 to 95 percent of the energy required for metabolism (Aumaitre and Seve, 1978), preventing weakness and losses to hypoglycemia and starvation. Since pigs do not receive maternal antibody in utero (Uerhahn, et.al., 1981; Blecha and Kelley, 1981), and are unable to produce their own antibodies until about day 10 (Wilson, 1974) it serves as the primary source of immunoglobulin (Ig) and other antimicrobial factors, such as lactoferrin, for the early immune system.

Energy Sources for the Baby Pig. The neonatal pig has few energy reserves at birth. The pig has a low fat content (1.1% vs. 2-10%) relative to other mammals, and this fat is mainly structural, allowing minimal utilization for energy (Steinman and Benevenga, 1985). This leaves three possible sources of energy: glycogen, protein, and ingested material (e.g. colostrum). When milk intake is inadequate or nonexistent, glycogen stores are capable of providing energy for approximately 18 hours (Mersmann, et.al., 1972). At this point, however, only protein is left as an energy source. If the neonatal pig continues to break down protein it will weaken and eventually die.

In this situation, it is obviously vital that the pig receive some external source of energy. This could be in the form of milk replacer, colostrum, dextrose solution, or fat. Steinman and Benevenga (1985) administered medium-chain-triglycerides to baby pigs, and their results suggested that this supplementation prolonged the availability of liver glycogen as well as suppressed protein breakdown.

Immunology of the Baby Pig. At birth, piglets are able to absorb intact colostral proteins through the intestinal lumen, and transport them into the blood stream (Miller et.al., 1962). Important among these are Immunoglobulins (Ig), iron- and vitamin-binding proteins, and lysozyme. As mentioned above, the survival rate of pigs is directly related to immunoglobulin intake (Gritsenko and Polidova, 1977; Hendrix, et.al., 1978; Blecha and Kelley, 1981). This is only logical, since its relatively long half-life of 14 days (Wilson, 1974) means Ig from colostrum will still be effective in the pig's system until the pig is old enough to produce its own. These passively acquired antibodies serve to protect the neonate from systemic diseases, which can contribute to the problem of early mortality. The iron- and vitamin-binding proteins reduce bacterial development by tying up nutrients needed by the bacteria to grow and multiply (Aumaitre and Seve, 1978). Primary among these is lactoferrin (LF), which binds iron (Reiter, 1978; Reiter, et.al., 1975; Law and Reiter, 1977; Griffith and Humphrey, 1977). In vitro work shows that LF iron-binding capacity is inhibited at a pH lower than 6.0, and is offset by competition from citrate. Law and Reiter (1977) suggested that LF is probably most effective within several hours of ingestion, before it is affected by the low stomach pH. In addition, they felt the higher pH in the duodenum would later restore the iron-binding capacity of lactoferrin. This could be enhanced further, since citrate, also found in the colostrum, is rapidly absorbed in the small intestine (Griffith and Humphrey, 1977), removing this extra source of competition. One important microorganism believed affected by LF activity is Escherica coli. Finally, some lysozyme is found in colostrum. Lysozyme has a multiple role in the immune system--it is involved in intracellular killing and digestion of phagocytosed bacteria (Reiter, 1978), secretory 11S IgA and complement are inactive in absence of lysozyme, and it has been shown to increase the rate of bactericidal activity of IgM with complement (Hill and Porter, 1974). Adequate intake levels of these substances are vital to baby pig survival.

Piglets are only able to absorb these unaltered proteins for about 24 hours (Wilson, 1974). The cut-off point is determined by closure of the gut to these large, undigested molecules. The specific trigger for this has been debated, with possible explanations including an absolute time factor, or filling of a certain number of Ig receptors (Bruegger and Conrad, 1972).

However, Lecce (1973) showed that when piglets were starved, protein uptake ability did not diminish at all, and transport ability did not decrease for three days, ruling out the time factor. And Uerhahn, et.al. (1981) found that lactose ingestion caused an absorption cut-off just as effectively as colostrum, rejecting the theory of IgG receptors. Instead, they concluded that the closure trigger was simply nutrient intake. If this is the case, quality of early colostrum consumed by the pig may be nearly as important as quantity; his immune system will only be supplemented by as many immune factors as are present in that first critical volume of milk.

Colostrum Intake. Many conditions may affect both quantity and quality of colostrum intake, as well as absorption of immune factors. Not surprisingly, this list corresponds closely to the previous section discussing influences on mortality. The amount of colostrum the baby pig receives is increased with heavier birth weights, smaller litters, quiet mothers, and early position in birth order (Aumaitre and Seve, 1978; Hemsworth, et.al., 1976), and adversely affected by cold stress (Blecha and Kelley, 1981; Kelley,et.al., 1981; Kelley, et.al., 1982). Larger pigs not only compete better for teats, tending to claim one that is sensed initially as high-yielding (Hemsworth et.al., 1976), but they are also vigorous enough to do a better job of draining the teat, causing greater subsequent milk flow. Competition is obviously reduced with small litters, and pigs with calm dams are able to just concentrate on eating, rather than moving, avoiding being crushed, and relocating a teat. Birth order is a factor both because early pigs can begin nursing with little or no competition, and because first milk is more easily obtained. Fraser (1984) found that colostral milk yield per teat was sharply reduced by several minutes of continuous milking, and that after an initial high yield (lasting 10 to 15 minutes) there were only discrete ejections of milk. These tended to last one to four minutes, involved anywhere from 2 to 20 grams of milk, and came from five to 30 minutes apart, with possible stimuli including birth of a pig, squeals, sounds of other sows nursing, or physical stimulation of the teat. As a result, later-born pigs have to work harder for their first meal. Cold stress may also decrease the acquisition of colostral Ig (Kelley et.al., 1982), by reducing suckling vigor and total milk intake

Birth order is also a major factor in determining the quality of colostrum a piglet receives, for the percentage composition of a sow's milk begins changing soon after milk flow begins. Morgan and Lecce (1964) labeled the entire first 72 hours of lactation the "parturition phase," but they found that after only 24 hours, nutrient levels in colostrum dropped from 18 to 5% protein and 28 to 16% dry matter. The make-up of the protein portion also shifted, from 80% whey proteins to 50%. Bourne (1969) took intermediate samples within that first 24 hour period, and found that colostral whey proteins fall 50% within four to six hours following the birth of the first piglet

(19.6g/dl to 10.5g/dl). Gamma globulins fell the most dramatically, from 8.6g/dl at zero hours to 3.9g/dl at six hours to 0.9g/dl at 24 hours. There was noticeable variation between sows in these absolute levels, but not in the rate of fall. Rate of fall was not affected by litter size or duration of farrowing, meaning late pigs from prolonged parturitions would be at an extra disadvantage. Bourne (1969) also commented that, in this regard, foster pigs were especially at a loss. Coalson and Lecce (1973) illustrated this point by preventing half the pigs in five litters from nursing for the first four hours. When measured at 28 hours, "first-nursers" had increased their serum gamma globulins over twice as much as the delayed pigs, and fifteen percent of the late feeders had such low serum Ig levels, their survival was doubtful. Some work has been done where all pigs in a litter were removed as they were born, and then returned to the sow as a group, giving all an equal chance at the first colostrum. Bourne (1969) found that when suckling was prevented this way for four hours, the whey proteins in colostrum did not go through the normal decline. After the pigs were allowed to nurse, he found the colostrum followed the percent change pattern found with natural suckling, with only a slightly faster fall in colostral whey protein concentration, giving every pig opportunity to consume the high quality milk. However, he did not evaluate any measurements of improved litter performance or survival. Hendrix et.al. (1978) repeated this procedure, removing 20 litters of pigs from their dams as they were born, and returning them simultaneously. As compared to a control group, neither mean litter gamma globulin concentration or number of piglets surviving to day 21 were affected (P>.05). Actually, the controls tended to have a higher concentration of IgG than removed pigs, probably because early-born controls nursed longer, and early-born treatment pigs were weak enough by the return to the sow, their nursing vigor was diminished.

Certain conditions also affect absorption of macromolecules from whatever colostrum is ingested before the gut closes. Lecce (1973) found that uptake ability was lost sooner if pigs were fed less frequently (4 vs. 24 times/day), or if they were scouring. He reasoned that in both of these situations, more food and digestive secretions are pushed down to the lower intestine, from large feedings or rapid passage. Since the lower intestine normally is the last section to close, speeding up its exposure to food ingestion would speed up overall losure. The presence of certain substances, namely albumin and bovine colostrum or colostral whey, in the neonate's earliest diet, have been shown to enhance absorption of IgG (Owen et.al., 1961; Uerhahn et.al., 1981). Working with colostrum-deprived pigs, Owen's group found that orally administered Ig caused a significant increase in serum Ig, and an additional increase over those levels was obtained when albumin was given concurrently. They theorized the albumin protected the proteins from enzymatic digestion, resulting in this enhanced absorption of immune globulins. Uerhahn, et.al. (1981), also caused an increase in piglet serum Ig by administering gamma globulins. Another group of pigs received the IgG, followed immediately by bovine colostrum; their IgG absorption improved 50 to 70 percent. The same results were obtained when bovine colostral whey was used, rather than whole colostrum, ruling out casein as the cause for improvement. As with the albumin, the possibility of protection from digestion was suggested, or, more specifically, an antitrypsin action. The plausibility of this theory is enhanced by work done by Jensen and Pedersen (1982). Pigs were fed sow milk, purified swine serum Ig's, and either purified Sow Colostrum Trypsin Inhibitor (SCTI) or saline. IgG, IgM, IgA and specific antibodies were measured four and six hours after the experimental meal, and they found that SCTI statistically enhanced both IgG and IgA absorption. Another hypothesis (Uerhahn et.al., 1981) was that the bovine colostrum actually initiated endocytosis. One factor that doesn't seem to affect absorption efficiency is intake volume. Over the range of IgG administered by Uerhahn (one to eight grams) and Owen (five to fifteen grams), absorption was directly proportional to the amount ingested.

Administering Colostrum. Administration of colostrum or colostral components, in one form or another, has been the topic of numerous studies. Supplemental porcine Ig's (Owen and Bell, 1964; Scoot et.al., 1972) and bovine colostrum (McCallum et.al., 1977) have resulted in improved survivability. Resistance to *E. coli* infections has also been used as a parameter, with favorable results from added porcine colostrum (Wilson, 1974; Svendsen and Wilson, 1971), porcine serum (Kohler and Bohl, 1966; Svendsen and Wilson, 1971), bovine colostrum (Mensik et.al., 1978), porcine colostral whey, and purified IgG (Brandenburg and Wilson, 1974). When piglet serum IgG levels were measured, for specific indications of immunity responses to supplementation, responses were again generally positive. Select bovine milk proteins were fed by Lecce et.al. (1961) and Pierce and Smith (1967), with resulting increases in the pigs' serum profiles. Uerhahn, et.al. (1981) and Owen, et.al. (1961) fed purified immune globulins to colostrum-deprived pigs, with similar results. However, Kelley et.al. (unpublished, 1981) found that 1.9 grams of serum-derived porcine Ig, given within 12 hours of birth, did not increase the serum levels of Ig in baby pigs left on the dam. It may be that these benefits would only be significant for piglets already under conditions conducive to poor performance or survivability.

Whiting, et.al. (1983) did conduct a series of three trials designed to measure the effect of supplemental porcine Ig on low-birth-weight (<.9 kg) pigs. Experimental groups of 6-14 pigs were raised to 21 days on milk replacer under "commercial" (nursery with individual tiered wire cages) conditions. Survival rates were compared between a negative control, pigs allowed 12 hours nursing time, and those receiving dried, abattoir-derived Ig in their milk replacer for 10, 15 or 21 days. The only significant (P<.05) improvement in livability was found with continuous 21-day supplementation. All mortality was attributable to either colibacillosis or salmonella.

Summary. The practical application of this area of research, outside the area discussed by Whiting, would have to be supplementation with bovine colostrum. It should be available in most agricultural areas from local dairies, does not require complicated or expensive labratory procedures to procure, and can be stored easily, either by fermenting or freezing. Maidment (1982) brings up some questions as to the immunologic value of fermented colostrum; he showed IgG levels dropped 21% in 42 days when kept at 5 C, and 17% at 15 C. In light of this, fresh or frozen colostrum would probably be better for use in piglets. Work done by Owen et.al. (1961) suggests that better results could be expected with oral administration, versus parenteral. Remaining questions are how much colostrum to give, and whether it would be economically beneficial for all pigs, for only those predisposed to poor survival or immunological development, or for none. Situations to consider would correspond with those high-mortality groups discussed earlier: small pigs, pigs from large litters, pigs born late in the farrowing order, cold stressed pigs, and sick, especially early-scouring, pigs.

Another major concern, if benefits from giving colostrum are proven, is whether improvement in performance and/or survivability is due to the immunologic factors in the colostrum, or just from the energy. If the latter is the case, isocaloric milk replacer would be as effective as the colostrum, and could possibly be more convenient and/or economical.

Methodology

<u>Feeding Trial</u>. Seven hundred fifty one pigs from three farrowings of crossbred gilts were stomach tubed as part of their day-one processing, and received one of three treatments: (1) 20 ml bovine colostrum, (2) 20 ml milk replacer, or (3) non-supplemented control.

The colostrum used was from a first milking of one of Kansas State University's second calf Holsteins, and had been stored froen in plastic containers. It was thawed in warm tap water. The milk replacer, manufactured by Land-O-Lakes, was mixed at a rate of 45 grams in 250 ml of solution. This was a little more than twice the recommended concentration for the replacer, and yielded a product isocaloric to the colostrum, with approximately 122.6 cal/ml of solution (determined by bomb calorimetry). Control pigs were tubed, but received no liquid. Treatment assignment was random, and was blocked by litter and size. Neonates weighing less than 1.09 kg were labeled 'smalls,' those weighing 1.09 to 1.32 kg were classed 'medium,' and any pig 1.33 kg or over was considered 'large.'

Pig and litter number were recorded, along with birth weight and weight class, treatment, sex, date of birth and litter size. After a minimal number of transfers were made, to somewhat even out litter size, pigs remained on the sows until weaning at approximately three weeks of age (range 15-27 days). From day 2 until weaning, pigs were scored on scouring. Each crate was checked for signs of scours, and when present, each pig's backside was examined individually to try and determine which animals were involved. The following scale was used to rate the pigs daily:

1 = none apparent

2 = pasty

3 = loose

4 = watery.

By the final week of the first farrowing, scouring was severe and almost universal; in the third farrowing, scouring was almost nonexistent. It was not certain whether the cause of the scours was E. coli, streptococcus, and/or coccidia.

Pigs were weighed at weaning, and these values were adjusted to account for variability in age. The adjusted weight was calculated by multiplying the weaning weight times age at weaning plus 6, and then dividing by 27. Weight gain was determined by finding the difference between birth weight and the adjusted weaning weight.

All deaths occurring before day 21 were recorded, including the day of age at death.

<u>Statistical Analysis</u>. The Statistical Analysis System (SAS) program at Kansas State University was used for all computations. The mean, standard deviation, range and variance were obtained for the numeric variables (litter size, birth weight, weaning weight(adjusted), weight gain, and age at death). These values were also broken down by treatment, by litter size, and by treatment and weight class.

Frequency tables were developed for day of age at death and the daily scour scores, both overall and by treatment/weight class combinations.

Analysis of variance was used to determine if there were any significant effects on weight gain, weaning weight, survival, or scouring. The GLM (General Linear Models) procedure was used for weight gain and adjusted weaning weight, with source variables treatment, litter size, and weight class. Appropriate interactions were also examined. (See Appendix C for statistical models).

Before the scouring and death data were analyzed,they were grouped in the following manner:

1. the critical first two days
2. days 3-5
3. days 6-8
4. days 9-11
5. days 12-14
6. the third week (days 15-21).

Death losses were expressed as a percentage. Values from each time period were averaged for individual pigs, creating new variables (e.g. average scours 1, death 2). These data were then analyzed using the three farrowings as replications. The ANOVA (Analysis Of Variance) procedure was used, and source variables were days, treatment, and size, with interactions.

Economic Analysis. Two major issues were addressed: 1) if the colostrum would be available to pig producers, and 2) if the use of colostrum for pigs would be economically justifiable.

An informal survey was taken of producer participants at Kansas State University's 1985 Dairy Day, asking the following three questions (see appendix for copy of actual questionnaire):

1. Do you produce more colostrum than you need for your calves?

2. Would you consider selling any excess to area swine producers?

3. A. What would you charge per gallon?
   B. Is this (more than, same as, or less than) you would charge for on-farm milk?

An enterprise budget was then prepared to illustrate the expected costs per pig from treating with 20 ml of colostrum. The stomach tube was priced at the ammount paid to the Kansas State University College of Veterinary Medicine for the tube used in the trial (see appendix for illustration). It was assumed the tube would last for 1,000 uses; the tube used in the trial showed no wear after approximately that number of dosages. The syringe price (disposable, 30cc) was obtained from the local Co-op, and divided over the average number of pigs per litter (experiment value), since one litter would probably be the smallest number of pigs treated at a time, and thus with one syringe. The average survey response for price charged for colostrum was used in the economic analysis. And finally, a labor value was obtained from USDA's Agricultural Prices. A total cost per administration was then estimated.

A table was prepared which allowed comparison of total cost and expected returns, with various levels of death loss reduction and price per pound. The assumption was made that pigs weighed

4.77 kg (10.5 pounds) when weaned, using the mean value from the feeding trial.

Results

Descriptive Statistics. Means, standard deviations, and the minimum and maximum values were obtained for each of the numeric variables (Table 1). Average birth weight for pigs used in the trial was 1.15 kg, and ranged from .45 to 1.86 kg. When broken down by treatment, and then by treatment/ weight class combinations, these values were essentially the same, indicating an even distribution of treatment assignment. The mean for weight gain was 3.63 kg, with a fairly wide range spanning .45 to 7.86 kg. Weaning weights were adjusted, as previously discussed, with the following formula:

weaning weight x (age at weaning + 6) / 27.

The overall mean for this value was 4.80 kg, ranging from 1.50 to 8.82. The average litter size was 9.98, and ranged from 2 to 15. The mean for pigs weaned per litter was 8. Tables 2 and 3 illustrate the distribution of these values over the various treatment and birth weight class combinations.

Table 1. Mean, Range, and Standard Deviation for Selected Variables in the Pig Feeding Trial.

	N	Mean	Standard Deviation	Minimum	Maximum
Birth Weight (k)	751	1.15	.267	.45	1.86
Adj. Weaning Wt. (kg)	672	4.80	1.40	1.50	8.82
Weight Gain (kg)	672	3.63	1.35	.45	7.86
Litter Size	84	9.98	2.58	2.00	15.00
Pigs Weaned/Litter	84	8.00	3.03	2.00	14.00

Notice that weight gains and weaning weights were slightly higher for pigs treated with colostrum. However, when broken down by size groups, this relationship was not always consistent. In the case of the "small" pigs, where greater magnitudes of improvement were expected, both the colostrum and replacer pigs gained and weighed more than the controls, although this difference was not significant.

Table 2. Weight Gain Means, by Treatment and Treatment/Weight Class Combinations.

Treatment	N	Mean	Standard Deviation	Minimum	Maximum
		kg			
Colostrum	224	3.67	1.35	.50	7.86
Large	65	3.80	1.36	.55	7.14
Medium	79	3.74	1.25	.50	6.50
Small	80	3.50	1.42	.59	7.86
Replacer	221	3.60	1.39	.73	6.95
Large	61	3.52	1.55	.73	6.45
Medium	80	3.70	1.41	1.05	6.95
Small	80	3.58	1.22	1.05	6.54
Control	227	3.61	1.31	.45	7.77
Large	63	3.65	1.47	.86	6.50
Medium	80	3.78	1.33	1.32	7.27
Small	84	3.42	1.15	.45	7.77

Table 3. Weaning Weight Means, by Treatment and Treatment/Weight Class Combinations.

Treatment	N	Mean	Standard Deviation	Minimum	Maximum
		kg			
Colostrum	224	4.85	1.40	1.55	8.82
Large	65	5.29	1.38	2.32	8.55
Medium	79	4.93	1.25	1.68	7.64
Small	80	4.41	1.45	1.55	8.82
Replacer	221	4.78	1.43	1.95	8.23
Large	61	5.02	1.60	2.09	8.23
Medium	80	4.89	1.41	2.36	8.14
Small	80	4.47	1.26	1.95	7.50
Control	227	4.76	1.36	1.50	8.68
Large	63	5.11	1.49	2.45	7.91
Medium	80	4.96	1.34	2.50	8.50
Small	84	4.30	1.16	1.50	8.68

Percent survival is shown, by treatment and birth weight classes, in Table 4. As expected, survival rates decreased with size. In addition, pigs treated with colostrum displayed the highest survivability, and control pigs the lowest.

Table 4. Percent Survival, by Treatment and Weight Class.

	treatment		
Weight Class	Colostrum	Replacer	Control
Large	97.01	98.38	94.02
Medium	92.94	90.90	89.88
Small	85.10	81.63	83.16
Overall	91.05	89.11	88.32

The mean statistics were also calculated for the variable day of age at death (Table 5). Death losses in colostrum treated pigs tended to occur earlier in life, while those in replacer and control pigs centered more around days 8 to 14 when scouring was most prevalent.

Table 5. Age at Death Means, by Treatment and Treatment/Weight Class Combinations.

Treatment	N	Mean	Standard Deviation	Minimum	Maximum
Overall	78	7.78	5.83	1	20
Colostrum	22	5.2	5.57	1	20
Large	2	6.0	4.24	3	9
Medium	6	7.0	6.42	3	20
Small	14	4.4	5.53	1	19
Replacer	27	9.2	5.31	1	17
Large	1	9.0	--	-	--
Medium	8	11.6	4.57	3	17
Small	18	8.1	5.52	1	17
Control	29	8.4	6.04	2	20
Large	4	9.5	8.18	2	18
Medium	8	7.9	6.56	2	20
Small	17	8.4	5.67	2	19

The age-at-death data were also arranged in a frequency table (Table 6). Losses were highest days 2 and 3, and peaked again with the severe scours present days 9 to 11.

Table 6. Death Loss Occurrence by Day of Age.

Age at Death	Frequency	Age at Death	Frequency	Age at Death	Frequency
1	4	8	1	15	4
2	15	9	6	16	0
3	13	10	1	17	3
4	3	11	8	18	2
5	4	12	2	19	2
6	2	13	3	20	2
7	0	14	3	21	0

Weaning Weight. Analysis of variance was used to determine if adjusted weaning weight was affected by treatment, litter size, weight class, or interactions of these variables. Weight class and litter size were both significant at the .0001 level, but neither interaction with the treatment variable was significant (see appendix).

Weight Gain. Analysis of variance results were similar as those for weaning weight. Litter size again had a significant effect on performance (.0001 level), with 13 degrees of freedom. Weight class, with 2 degrees of freedom, only had a P-value of .0709. None of the interactions were significant (see appendix).

Scouring. Daily scour scores were grouped into six periods and averaged. Sample means were then calculated for the pigs involved in the experiment, broken down by treatment, weight class and farrowing (Table 7). Control pigs tended to scour more, but an analysis of variance on treatment, size, and interactions with days showed no significant effects (see appendix). Scours were significantly worse overall from days 9 to 14.

Table 7. Average Scour Scores for Selected Brackets of Days, by Treatment, Weight Class, and Farrowing.

TREATMENT:	----Colostrum----			-----Control----			----Replacer-----		
WT. CLASS:	L	M	S	L	M	S	L	M	S
DAYS									
Farrowing 1.									
1-2	1.030	1.028	1.000	1.125	1.053	1.011	1.016	1.012	1.022
3-5	1.000	1.000	1.000	1.000	1.000	1.015	1.000	1.000	1.022
6-8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9-11	1.083	1.034	1.061	1.143	1.149	1.069	1.123	1.111	1.095
12-14	1.189	1.083	1.288	1.253	1.204	1.250	1.298	1.270	1.252
15-21	1.085	1.196	1.167	1.170	1.161	1.143	1.122	1.128	1.177
Farrowing 2.									
1-2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3-5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.067	1.011
6-8	1.000	1.053	1.038	1.000	1.042	1.092	1.000	1.040	1.100
9-11	1.121	1.042	1.115	1.286	1.139	1.119	1.273	1.056	1.172
12-14	1.273	1.097	1.103	1.119	1.125	1.095	1.061	1.069	1.060
15-21	1.029	1.051	1.152	1.000	1.066	1.055	1.175	1.048	1.159
Farrowing 3.									
1-2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3-5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6-8	1.000	1.000	1.000	1.000	1.028	1.032	1.033	1.016	1.000
9-11	1.091	1.061	1.000	1.083	1.000	1.063	1.050	1.016	1.111
12-14	1.061	1.015	1.074	1.117	1.000	1.033	1.100	1.000	1.067
15-21	1.000	1.000	1.024	1.000	1.000	1.071	1.000	1.000	1.000

The largest discrepancies in scour scores were found between farrowings, rather than treatments or weight classes. In the first farrowing, scours affected most litters, many quite severely, while in the third farrowing, scours were almost unseen. The second group of pigs also displayed fairly widespread scouring. This variability may have affected the reliability of the statistical analysis. It was not known what specifically caused the scours, or if the scouring in every farrowing was from the same cause. If, in fact, some of the scours were due to coccidia, then the colostrum treatment could not have been expected to improve resistance as in the case of E. coli scouring. In addition, the handling of the data reduced the analysis of variance degrees of freedom to 2, even though over 700 pigs were involved in the observations.

Survival. The data were expressed as a percent death loss, grouped in the same day brackets used to analyze scouring. Analysis of variance showed days and size to be highly significant (P-values of .0078 and .0001, respectively). And in the days/weight class interaction, death loss was significantly higher in small pigs on days 1-2, 6-8, 9-11 and 12-14, and in smalls and mediums (relative to larges) days 3-5. The three-way interaction between treatment, days and size suggested an effect with a P-value of .1121. The death losses are shown, by treatment, days, and weight class, in Table 8, while results from the analysis of variance are again presented in the appendix.

Table 8. Percent Death Loss for Selected Brackets of Days, by Treatment and Weight Class.

TREATMENT:	Colostrum			Replacer			Control		
WT. CLASS:	L	M	S	L	M	S	L	M	S
DAYS									
1-2	0.00	0.00	9.43	0.00	0.00	7.02	1.45	2.22	2.02
3-5	1.01	5.91	3.21	0.00	1.51	3.03	1.04	2.19	4.32
6-8	0.00	0.00	0.00	0.00	0.00	2.08	0.00	0.00	1.55
9-11	2.78	0.00	0.00	1.04	2.96	4.90	0.00	1.75	2.77
12-14	0.00	0.00	0.00	0.00	0.85	2.00	0.00	0.92	3.29
15-21	0.00	0.95	1.71	1.07	2.63	0.88	2.15	0.95	1.80

The Least Significant Difference (LSD) for this table was .930. Planned comparisons involved values within a day bracket and weight class, and between treatments. Most significant differences followed the expected pattern of colostrum < replacer < control, but some did not. Especially disturbing are the values for days 1-2, where control death losses were considerably less than the other treatments. This relationship would possibly be reversed if larger numbers of pig losses were involved.

The most consistent results were found where the strongest response was expected--among small pigs during the high scouring period. In days 6-8, small colostrum pigs showed no death loss, replacer-treated pigs 2.08%, and control pigs 1.55%. In days 9-11, values were colostrum 0.00%, replacer 4.90%, and control 2.77%. And from day 12 to 14, an additional 2% of the replacer pigs were lost, and 3.29% of the controls, still without a small/ colostrum pig death. It should be noted here that of the 22 colostrum treated pigs that died, only 3 (13.6%) had shown any scouring at all. In contrast, 37% (10 of 27) of the dead replacement treated pigs had scoured, and 31% (9 of 29) of the controls.

Economic Analysis. Approximately half of the 25 dairymen surveyed indicated that they did routinely have excess colostrum, and the same number said they would sell it to local hog producers. Only 13 indicated a probable charge for the colostrum, with an average of $1.83 per gallon (range $1-5). Three producers said they would charge more for colostrum than for on-farm milk, six said they would charge the same, and only one felt he would want less for the colostrum than the milk.

Taking these responses to mean that colostrum would be available to Kansas pig producers, an analysis was done to determine when day-one treatment would be economically justifiable. There are basically four input costs involved in treating pigs as discussed: a stomach tube, syringe, the colostrum, and labor time. The tube used in the trial cost $3 at the KSU College of Veterinary Medicine. An arbitrary number of 1,000 uses was chosen to spread the cost of the tube over, leaving

\$.003 per pig. The tube used for this experiment had given approximately that many doses with no signs of wear. A 30 cc disposable syringe was priced at \$.80 at a local co-op. Since one litter would probably be the smallest number of pigs dosed with one syringe, the 80 cents was divided by 10--the average litter size from the feeding trial. This corresponds closely to the 10.46 pigs per litter reported in a recent survey of Kansas pork producers (Bandyk, 1983). Using the Dairy Day survey average price of \$1.83 per gallon of colostrum, a 20 ml dose would cost \$.0097. It takes about 30 seconds for a practiced worker to dose a piglet, and at the wage rate cited in USDA's <u>Agricultural Prices</u> (\$.070/minute), that adds \$.035 to the input costs.

Taking all these assumptions, the total cost per pig for colostrum treatment is \$.128. To see if the expected value gained will exceed this figure, Table 9 may be used. The experimental weaning weight mean of 10.5 pounds was used to convert percent reduction in death loss to additional pounds of pig. To use the table, select an expected reduction in death loss, and price per pound value for a weaned pig. The corresponding table value must be larger than your calculated critical value (the total input cost discussed above). In other words, with the conditions described in the preceeding paragraph and repeated under the table, colostrum treatment would be a good investment whenever your expectations match a value located to the lower right of the broken line.

If, on the other hand, you have labor working for minimum wage (\$3.35/ hour), and plan to treat five litters with each syringe, your critical value would only be \$.057:

$\$3/1000 + .80/50 + .01 + (.5 \times 3.35/60) = .003 + .016 + .010 + .028 = \$.057.$

Then treatment should be given any time expectations match those values found inside the solid line. Dosing the pigs with a re-usable syringe could also affect the decision of when to use this treatment, since that would totally eliminate the syringe cost. If that were the case, and labor was to be provided by a young son or daughter working for \$1/hour, with 5 litters (50 pigs) per syringe, the value gained would only have to exceed \$.0273. Then it would only take a .5% reduction in death loss to more than pay for the treatment, providing pigs were worth over \$.50/pound.

Table 9. Value Gained Per Pig With Various Reductions in Death Loss and Per Pound Pig Values.

% DEATH REDUCTION:	0.5	1.0	1.5	2.0	2.5
* ADDIT'L LBS. PIG:	.053	.105	.158	.210	.263
Price Per Pound	value gained (cents)				
$ .40	2.12	4.20	6.32	8.40	10.52
$ .45	2.39	4.73	7.11	9.45	11.84
$ .50	2.65	5.25	7.90	10.50	13.15
$ .55	2.92	5.78	8.69	11.55	14.47
$ .60	3.18	6.30	9.48	12.60	15.78
$ .65	3.45	6.83	10.27	13.65	17.10
$ .70	3.71	7.35	11.06	14.70	18.41
$ .75	3.98	7.88	11.85	15.75	19.73

Critical Value = tube cost + syringe + milk + labor

Example = $.003 + $.08 + $.01 + $.035 = $.128

* assuming a 10.5 pound weaning weight

Conclusions

Newborn pigs were given 20 ml of bovine colostrum or milk replacer through a stomach tube, and their growth, scouring, and survival were evaluated between treatments and against a group of control animals. Results were broken down by weight class: small = < 1.09 kg; medium = 1.09 to 1.32 kg; and, large = > 1.32 kg.

It was anticipated that the supplemental colostrum would improve weight gains, weaning weights, scouring problems, and/or survivability by providing additional energy and immunologic factors to the pigs. The replacer served as an alternate source of an equal amount of energy, but naturally lacked the immune substances.

Analysis of variance showed no significant responses in adjusted weaning weight or weight gain from either treatment.

Control pigs tended to scour more, but again the differences were not statistically different. However, the handling of the data reduced the degrees of freedom to 2, even though over 700 pigs were involved in the observations. It was not determined what specifically caused the scouring to occur, or if all scours were of the same type. There was a possibility that the severe scours in the first farrowing were a result of a coccidia infestation, in which case the colostral components would not be efficacious. Overall, scours were worse from days 9 to 14.

Survival data were expressed as percent death loss, and significant differences were found between size groups (higher for smalls) and days of occurrence (higher days 3-5 and 9-11).

Analysis of variance run on a weight class/days interaction showed a significantly higher death loss in small pigs on days 1-2, 6-8, 9-11, and 12-14 (vs. medium and large for the same days), and small and medium pigs (relative to larges) days 3-5. The three-way interaction between treatment, days and size had a P-value of .1121. Significant differences were found between small colostrum treated pigs and the other small pigs during the period of most severe scouring (days 9-14). This suggests that the colostrum supplementation would reduce death loss related to scouring (e.g. E. coli infections). And this is further augmented by the fact that only 3 of the 22 colostrum treated pigs that died had displayed any scouring at all (and one of them only a one-day score of "2", or "pasty"), while approximately one-third of the other lost pigs were known to have scours before they died.

An economic model was prepared to analyze the profitability of day-one colostrum supplementation. Various combinations of value per pound of weaned pig and expected improvement in death loss were used to calculate an expected gained value from the treatment. This figure is then compared to a critical value, or total input cost, which contains per pig costs for a stomach tube, syringe, milk, and labor. When value gained is greater than the expense, colostrum dosing should be practiced. Examples used showed that this may often be the case.

There are several directions further research in this area could take. Initially, more repetitions would be desirable when discussing survivability, since actual death numbers were fairly low, and degrees of freedom were limited to two. In addition, cause of death should possibly be determined, to see if losses are related to energy levels or the immune factors present in colostrum, or not.

When considering the value of supplemental energy, research should be done to determine the optimal dose volume, and also the best source--both from a practical and an economic point of view. This study used colostrum and replacer, but other options include fat, and injections of dextrose. A related question is how this direct dosing compares to feeding the sow higher energy (high fat) rations to increase the energy content of her milk.

There may also be other sources of the immunoglobulins and other immunologic factors. And, no matter what the source, their action might be more accurately monitored if the pigs on trial were actually infected with a known E. coli, for example, to eliminate the problems found in this study with erratic and undiagnosed scouring and mortality.

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Appendix A. Dairy Producer Survey Sample

CURRENT RESEARCH IS SHOWING SOME PROMISE FOR SUPPLEMENTING DAY-OLD PIGS WITH BOVINE COLOSTRUM. WE WOULD APPRECIATE YOU INPUT AS A DAIRYMAN IN ANALYZING THE PRACTICALITY AND ECONOMICS OF IMPLEMENTING THIS PRACTICE ON KANSAS FARMS. PLEASE COMPLETE THE QUESTIONS BELOW. KEEP IN MIND THAT WE ARE NOT TALKING ABOUT VERY LARGE VOLUMES; 1 GALLON SHOULD TREAT UP TO 190 PIGS.

1.) DO YOU PRODUCE MORE COLOSTRUM THAN YOU NEED FOR YOUR CALVES? _____YES

_____NO

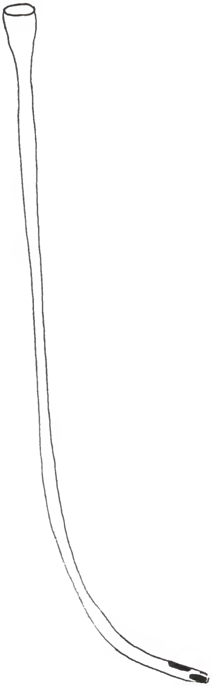
2.) WOULD YOU CONSIDER SELLING ANY EXCESS TO AREA SWINE PRODUCERS? _____YES

_____NO

3.) A. WHAT WOULD YOU CHARGE? _______/GALLON

B. IS THIS (MORE THAN, SAME AS, OR LESS THAN) YOU WOULD CHARGE FOR ON-FARM MILK?

Appendix B. Stomach Tube Used in Experiment



Appendix C. Analysis of Variance Models

BRTHWT = birth weight
ADJWT = adjusted weaning weight
WTGAIN = ADJWT - BRTHWT
TRT = treatment (colostrum, replacer, or control)
LTSIZE = litter size
WTCLAS = birth weight classification (small, medium, or large)
DAYS = multiple-day bracket (1-2, 3-5, 6-8, 9-11, 12-14, or 15-21)
AVGSC = average scour score over the days in the DAYS bracket
DEATH = average percent death loss over the days in the DAYS bracket.

1. WTGAIN = TRT LTSIZE WTCLAS TRT*WTCLAS

Source	DF	Type III SS	F Value	PR > F
TRT	2	5.2842	0.32	0.7290
LTSIZE	13	399.7602	3.68	0.0001
WTCLAS	2	44.4013	2.66	0.0709
TRT*WTCLAS	4	19.9864	0.60	0.6646

2. ADJWT = TRT WTCLAS TRT*WTCLAS LTSIZE TRT*LTSIZE

Source	DF	Type III SS	F Value	PR > F
TRT	2	6.3751	0.37	0.6889
WTCLAS	2	284.7800	16.66	0.0001
TRT*WTCLAS	4	17.5125	0.51	0.7269
LTSIZE	13	424.8949	3.82	0.0001
TRT*LTSIZE	41	588.6695	1.58	0.0139

3. AVGSC = DAYS TRT WTCLAS DAYS*TRT DAYS*WTCLAS TRT*WTCLAS DAYS*TRT*WTCLAS

Source	DF	Anova SS	F Value	PR > F
DAYS	5	.3829	18.88	0.0001
TRT	2	.0050	0.62	0.5404
WTCLAS	2	.0106	1.31	0.2737
DAYS*TRT	10	.0120	0.30	0.9809
DAYS*WTCLAS	10	.0475	1.17	0.3176
TRT*WTCLAS	4	.0023	0.14	0.9661
DAYS*TRT*WTCLAS	20	.0197	0.24	0.9997

Appendix C, continued.

4. DEATH = DAYS TRT WTCLAS DAYS*TRT DAYS*WTCLAS TRT*WTCLAS DAYS*TRT*WTCLAS

Source	DF	Anova SS	F Value	PR > F
DAYS	5	99.2471	3.34	0.0078
TRT	2	2.1524	0.18	0.8348
WTCLAS	2	136.0176	11.43	0.0001
DAYS*TRT	10	55.1008	0.93	0.5123
DAYS*WTCLAS	10	124.8009	2.10	0.0306
TRT*WTCLAS	4	8.2708	0.35	0.8452
DAYS*TRT*WTCLAS	20	173.4724	1.46	0.1121

SUPPLEMENTING DAY-OLD PIGS WITH
BOVINE COLOSTRUM OR
MILK REPLACER

by

Cathryn A. Bandyk

B.S. Kansas State University, 1982

AN ABSTRACT OF

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Pig producers need ways to wean more pounds of pigs without completely offsetting these gains with increased production costs, either through reducing mortality or improving early growth rate. Management practices that bolster nutrient (energy) intake and immune system development help accomplish these goals. An option that could provide both energy and immune factors is supplementation with bovine colostrum. Another alternative might be administration of milk replacer, which is a convenient, available source of energy.

In this study, 751 pigs from three farrowings of crossbred gilts were classed by birth weight (small = < 1.09 kg; medium = 1.09 to 1.32 kg; large = > 1.32 kg), and received one of three treatments: 1) 20 ml bovine colostrum, 2) 20 ml milk replacer, or 3) non-supplemented control. Pigs remained on the sows until weaning, and were evaluated for growth, scouring and survival. It was anticipated that the pigs supplemented with colostrum would, due to the available energy and immunologic factors, display less scouring and mortality, and possibly improved weight gains and/or weaning weights. Pigs receiving replacer were expected to perform at a level somewhere between the colostrum pigs and the controls.

Analysis of variance showed no significant responses in adjusted weaning weight or birth to three week weight gain from either treatment.

Pigs were checked daily for scouring, and scored individually, with a "1" signifying none apparent; "2", pasty; "3", loose; and "4", watery. These values were grouped and averaged into six multiple-day brackets: the critical first two days, 3-day periods through day 14, and the third week. Control pigs tended to scour more, but the differences were not significant when analyzed using the three farrowings as replications. Some of the scouring observed in the experiment may have been caused by coccidia, in which case the colostrum could not be expected to be efficacious.

Survival data were expressed as a percent death loss, and were grouped in the same day brackets as scour scores. Significant differences were found between size groups (higher for smalls) and days of occurrence (higher days 3-5 and 9-11). Analysis of variance on the weight class/days interaction showed significantly higher death loss in small pigs on days 1-2, 6-8, 9-11, and 12-14 (versus medium and large for the same days), and small and medium pigs (relative to larges) days 3-5. Significant differences were found between small colostrum treated pigs and other small pigs during the period of most severe scouring (days 9-14).

An economic model was prepared to analyze the profitability of day one colostrum supplementation. A variety of live pig values and expected reduction in death loss were used to illustrate that this may often be a cost effective practice.

Further work is needed to pinpoint survivability and bacterial response to colostrum supplementation, and optimal dosage volume.